SAN FRANCISCO, CALIFORNIA

Pacific coast flooding is generally associated with high seas and rains. Ocean storms accompanied by high winds have caused considerable erosion and damage to beach and coastal floodplain property. Inland rain storms, on the other hand, falling on the mountainous terrain cause major canyon and valley flooding. Both coastal and canyon flooding are dangerous high-velocity situations. Slow-rising and lower-velocity conditions occur on coastal marshes and low-lying riverbeds.

The architect has developed several very interesting and distinctive residential concepts for single- and multi-family housing. The use of landscaping, fences, and exterior decks minimizes the elevated appearance of the structures while providing functional visual highlights. Structurally the two concepts are quite different. Although both concepts use wood posts, the single-family residence uses a two-way structural grid supporting prefabricated housing units, while the multi-family structure is conventional wood frame construction built upon a wood-post-supported platform.

Parking for both residential concepts is under the structure.

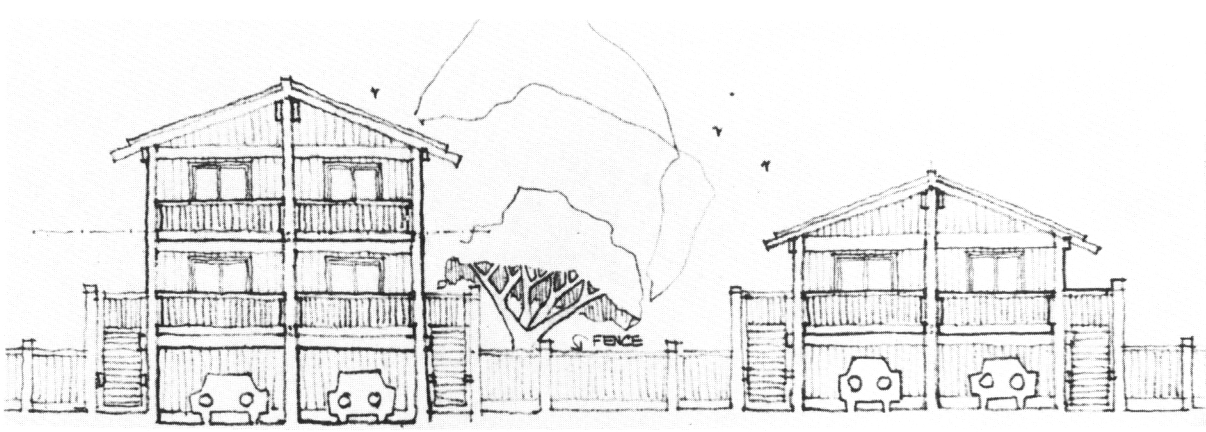


Figure 3.14

Single-Family Residential Concept

A two-way wood post structural grid supports the living units at levels above the base flood and serves to organize and unify the various units with minimal impact on the ecology of the area (Figures 3.14 to 3.16). A seven-foot clearance beneath the horizontal structural members allows for parking, storage, and sheltered recreation space separated from and below the living units. The reduced land coverage of this design is in keeping with the architect's concern for efficient land use. Shared facilities, clustering buildings, etc., further give these houses a unique identity and sense of community. Within the prescribed vernacular of poles, decks, railings, and fences, architectural variety with continuity is achieved. The fences are strapped together to prevent pieces from floating away if damaged during a flood. Water heater and furnace and air conditioning equipment are located 18 inches above base flood level with all ductwork in second floor or attic space.

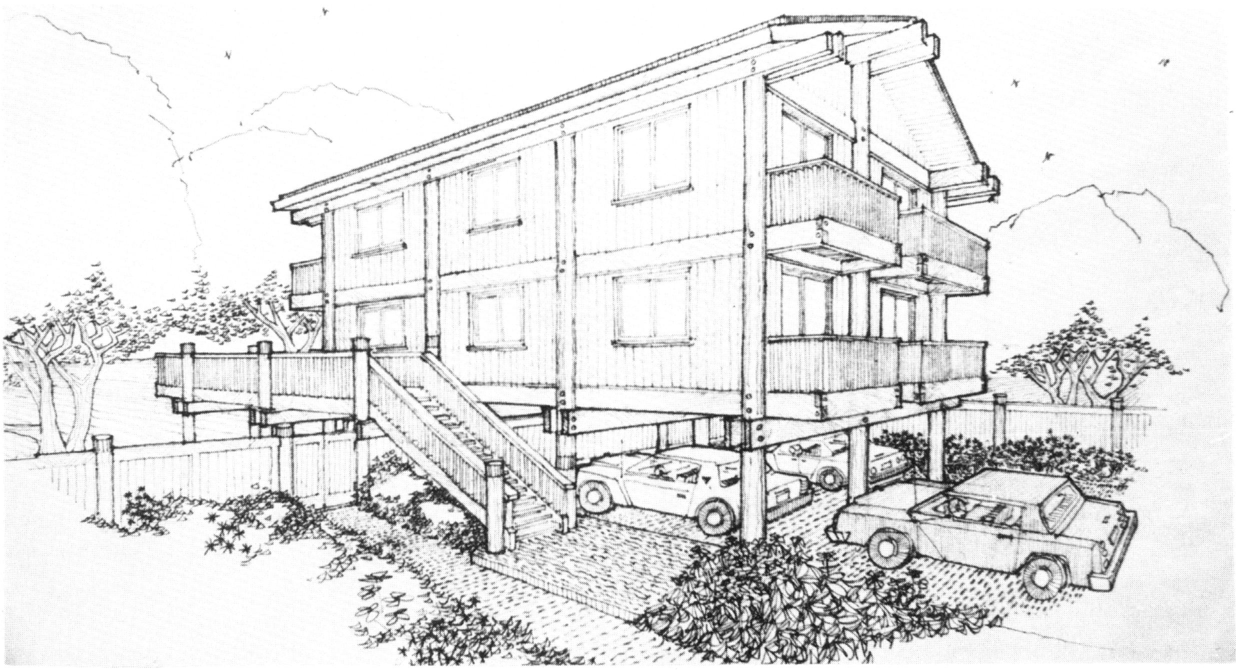


Figure 3.15

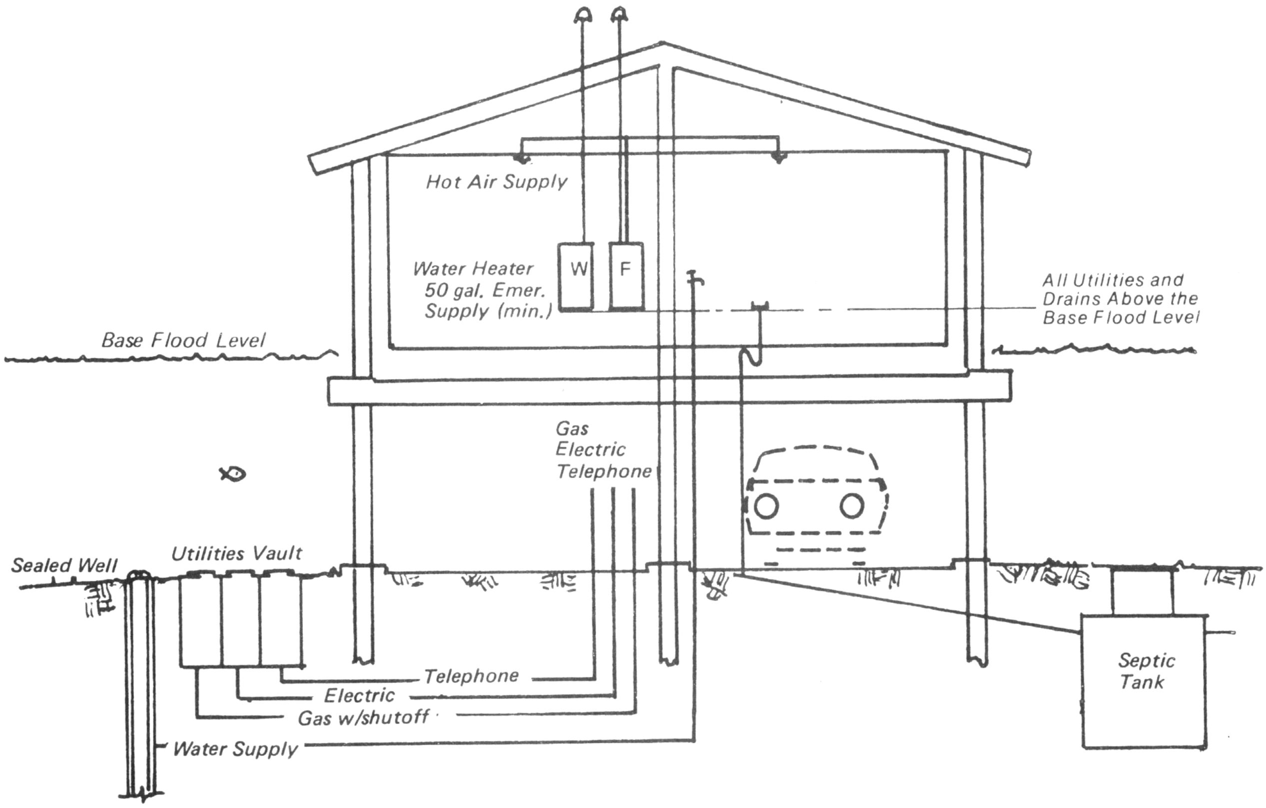

Hot Air Supply
W
F
Water Heater
50 gal. Emer.
Supply (min.)
All Utilities and
Drains Above the
Base Flood Level
Base Flood Level
Gas
Electric
Telephone
Sealed Well
Utilities Vault
Telephone
Electric
Gas w/shutoff
Water Supply
Septic
Tank

Figure 3.16

Multi-Family Residential Concept

To reduce costs, the architects have designed a conventional wood frame structure built upon a wood post platform (Figures 3.17 and 3.18). Raising the first floor to at least eight feet above grade provides an opportunity to put parking under the building. This reduces the area of the site that has to be built upon and places cars closer to apartments. However, parking under the structure requires fire separation. Exposed entrance stairs and fencing minimize the elevated appearance of the structure while providing visual variety and privacy.

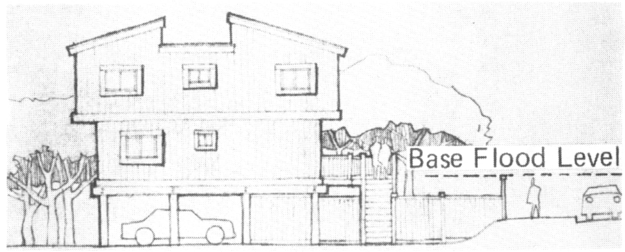


Figure 3.17

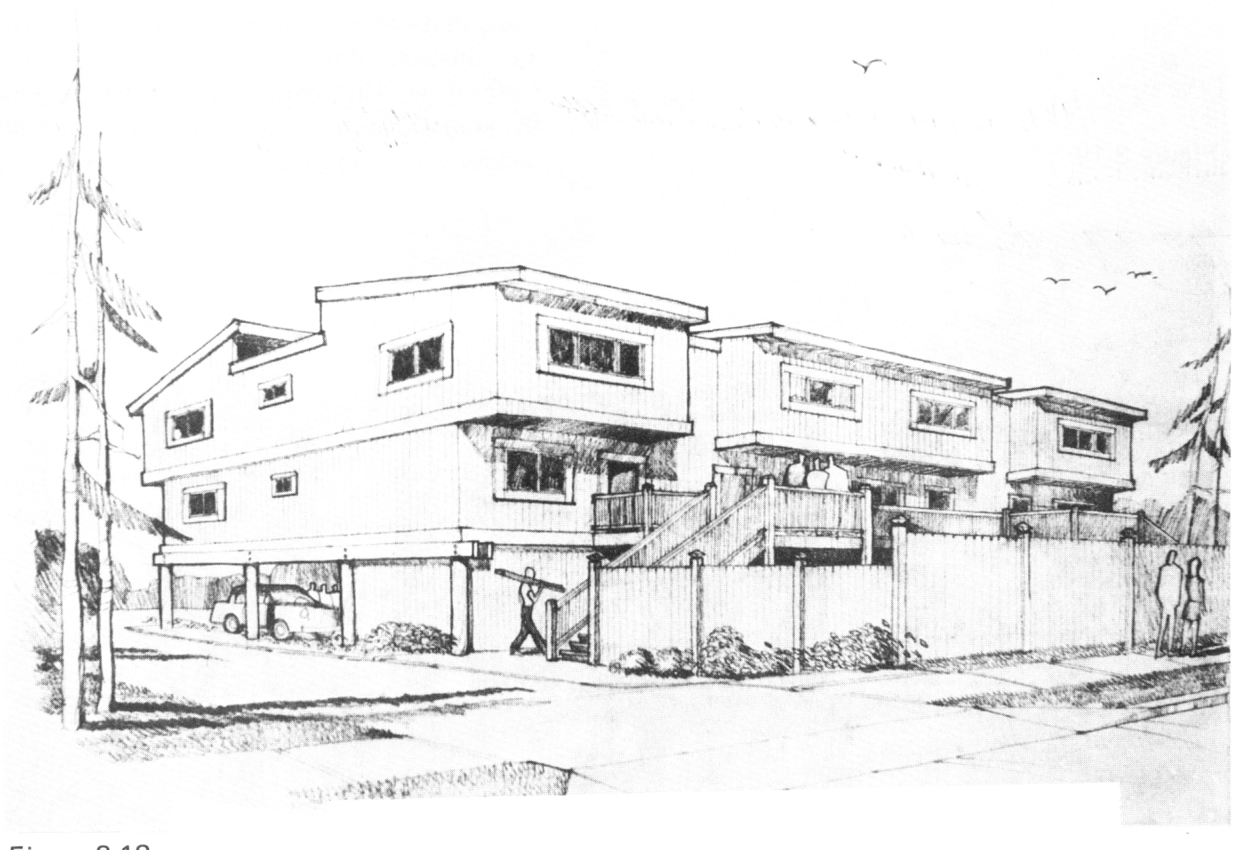


Figure 3.18

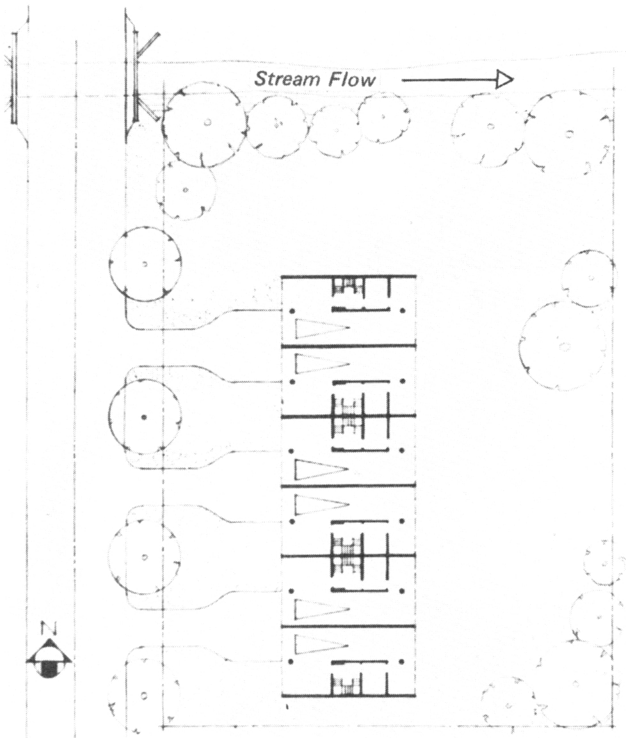


Figure 3.19

CHICAGO, ILLINOIS

Flooding in the Midwest is of two types: riverine and lake flooding. The characteristics of both are usually slow rise and low velocity. However, flash flooding and lake shore scouring can and do occur. The Great Lakes area, more specifically, the Wisconsin, New York, Ohio, and Michigan lake shores, have experienced growing problems of lake flooding and slow erosion caused by the increasing occurrence of high waters and high winds.

Garden Apartment Concept

Although elevated eight feet and constructed of reinforced concrete block, this rowhouse does not appear to be designed for a potential flood condition (Figures 3.19 and 3.20). The covered parking and entrance level is handsomely integrated with the above living levels by reinforced concrete block walls that organize the entire structure. The walls are constructed parallel to the direction of possible water flow. Unfortunately, the architect enclosed the stairway-entranceway, with a potentially serious effect on flood insurance rates.

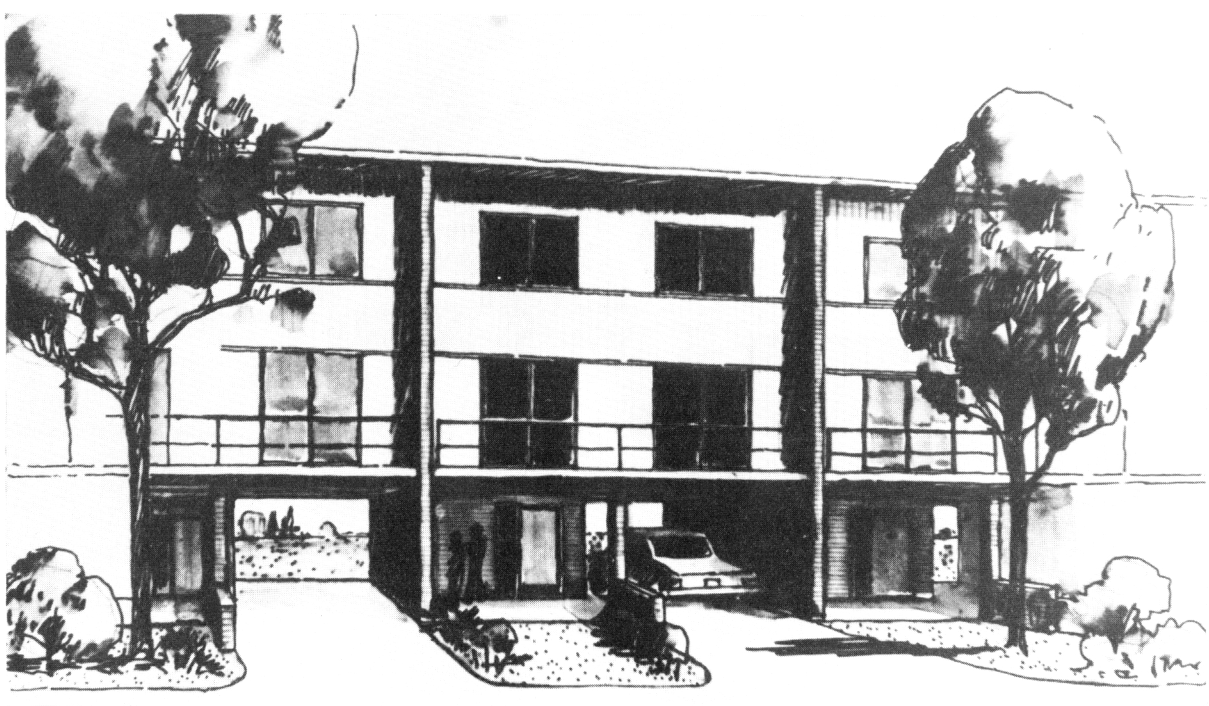
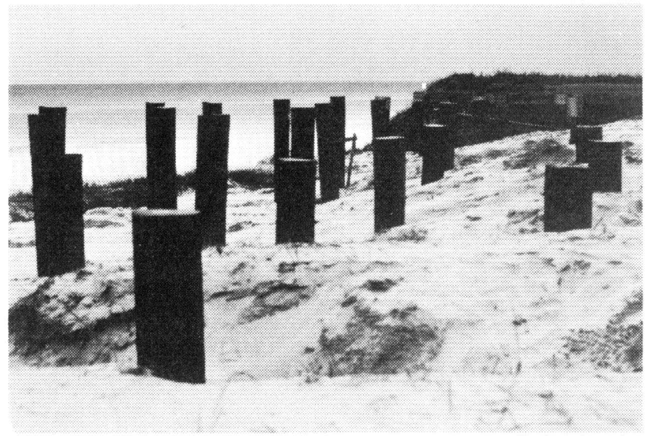


Figure 3.20

Aesthetic Considerations

There is a common misconception than an elevated residential structure will be inherently unattractive—a box on stilts (Figure 3.21). This is not true. Elevated structures offer challenging design opportunities to be aesthetically appealing as well as functionally sound.



Residential development requires a significant financial investment, and if it is aesthetically appealing it contributes to the economic value of the area, both for the owner and for the community as a whole. All communities have both positive and negative examples of this. Good quality tends to foster better quality, and poor conditions lead to even poorer conditions. Appealing design can thus be an important element of making the most of our limited development resources.

Figure 3.21

SITE DESIGN

Integration of development and site should be done so that the two complement each other. A careful site analysis can give many clues to the best design of the building for its relation to topography, location and orientation, and location of fenestration (views, etc.), entrys, and parking.

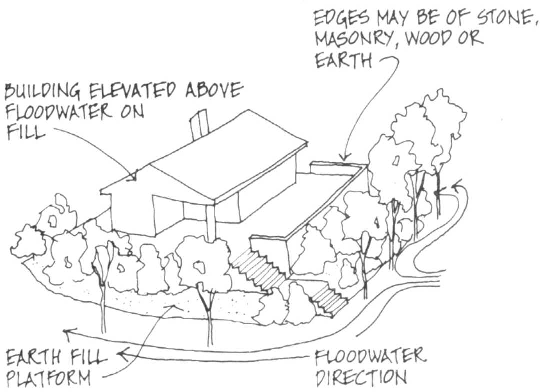


Figure 3.22

Landscaping—creative use of trees, shrubs, fences, walls, etc.—serves two purposes. It integrates the elevated portion of the development with its surroundings and, at the same time, helps control erosion and protect the dwelling from the impact of debris and fast-moving water (Figures 3.22 and 3.23).

The relationship and compatibility of development with the surrounding neighborhood and community should be considered in order to give a sense of continuity with the surrounding areas, rather than an unattractive "hodge-podge" of unrelated development.

Terracing and level changes can be used to give a sense of variety and to identify different uses, as well as to integrate building with site.

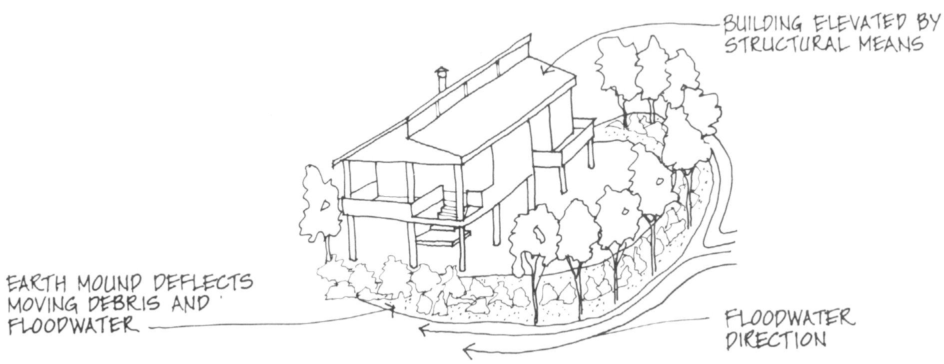


Figure 3.23

BUILDING DESIGN

The integration of the foundation with the site and the building is perhaps the most important aesthetic challenge when designing elevated structures. Many elevated structures give the impression that the support foundations are treated separately from the building and the site, giving the impression of a building set on spindly legs (figure 3.24). It is essential to recognize that the foundation is an integral part of a building, rather than only "something to set the building on." A well-designed elevated residence should provide a smooth transition from ground to dwelling, with the foundation integrated with and complementary to the building itself.

Other special considerations when designing elevated residences include the design of any needed stairs and the use of the areas under the structure. More general considerations include the shape and form of the building (configuration, shape of roof, etc.), textures and color of building materials, the use and treatment of balconies, terraces, railings, windows, shutters, screens, and entries, and the arrangement of interior spaces.

Figure 3.24

Figure 3.25. This wood structure successfully uses the same material throughout the building—foundation, structure, treatment of railings, wall, and roof material, as well as connection and anchorage details. The design honestly expresses the structure, foundations and other building elements. While it is obvious this is an elevated structure, it still feels very much a part of the site. The foundation members are also integrated well with the building itself (see also Figures 3.54 to 3.57).

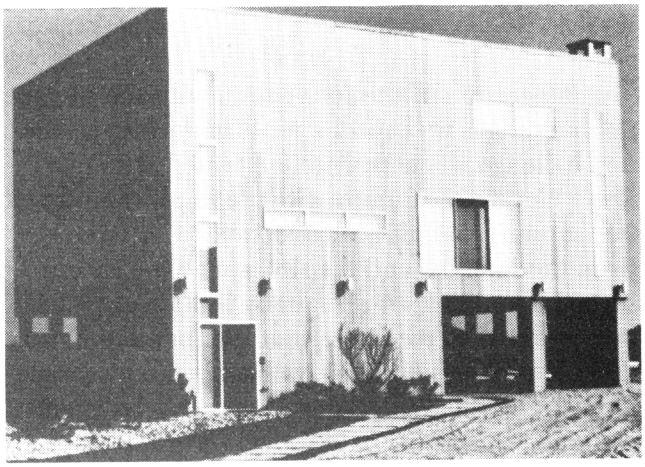
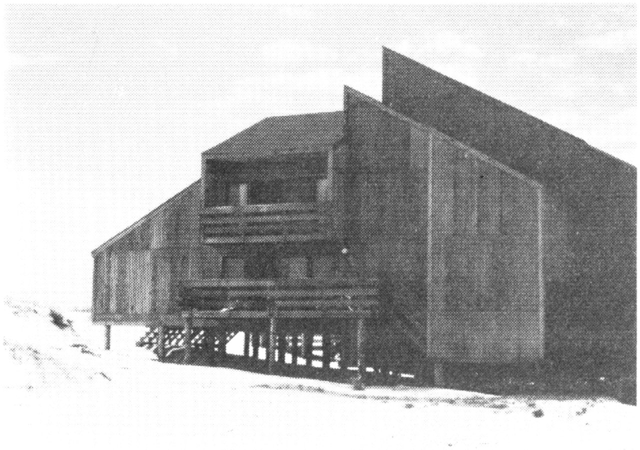
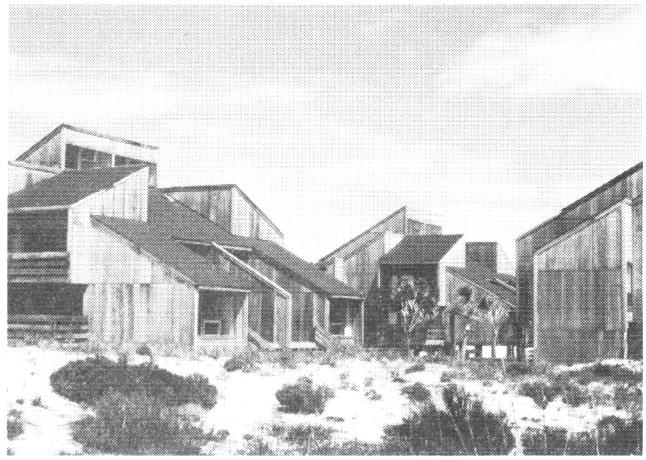


Figure 3.26. This is an example of integrating the site, the building, and the foundation so they relate well to each other. This foundation appears to be part of the building rather than stilts holding it up. It shows how a modest, simply designed building can also be very aesthetically appealing through the use of natural materials and interesting treatment of fenestration and lighting fixtures. Simple but well-thought-out landscaping ties the building effectively to the site.

Figure 3.27. This is a good example of how the configuration of a cluster layout can contribute to functional advantage as well as visual appeal. The sawtooth arrangement allows for two sides of each unit to have access/view to the ocean. This form also breaks up the long, continuous (and often monotonous) wall approach, thus adding variety and interest. With this configuration the materials, treatment and form of the units can be simple but still attractive.





Figures 3.28 to 3.29. This is an excellent example of cluster-type elevated residential development. The development is well-integrated with the site; the various levels seem to roll over and blend with the dune. The vegetation and simple fencing add much to this marriage. The individual units also relate very well to each other, providing a good example of an overall development's being "more than the sum of its parts." The individual units provide the individual amenities—privacy, plan layout, etc.—while still being a part of a comprehensive whole with a strong sense of community. The form, scale and character of the development are also excellent. The sloped roofs, the balcony treatment, use of levels, and the articulation of the other elements add variety and a character that complements the site and overall development. The use of materials—color, texture, scale—also contributes to the design's appeal (see also Figures 3.63 to 3.70).

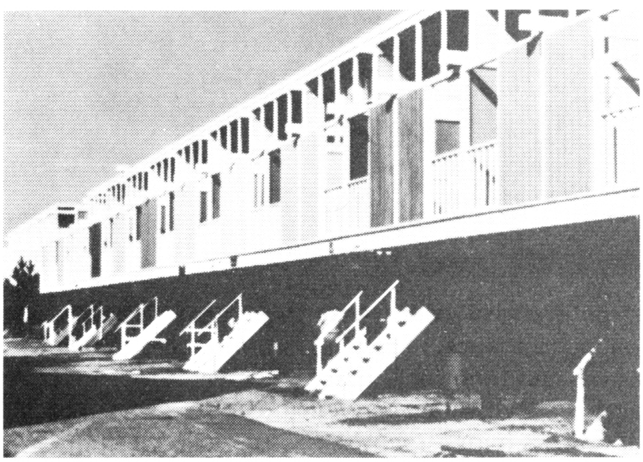


Figure 3.30. The exterior treatment of this development adds visual appeal to a development that could otherwise be quite monotonous. The exterior colored panels with white structure and coordinated interior panels provide interest, as does the simple treatment of balconies with a variety of planes, panels, railing and roof trellis members.

Figure 3.31. This is a good example of how a simple structural grid infrastructure can be used as a basis for a relatively modest, well-designed and visually appealing residence. The plan is simple, developed around the columns, but provides a very livable, interesting and functional space. The cantilevered balconies also add interest as well as defined exterior areas. The roof shape contributes to a spacious interior that makes the house feel larger than it really is, allows in natural light through the transom windows, and through its form adds much to the overall aesthetic appeal of the design (see also Figures 3.40 through 3.45).

Figure 3.32. The diagonal battens used to enclose the stairwells for protection provide an aesthetically appealing screen-textural affect. The colored awnings also add a necessary highlight to an otherwise colorless exterior. Notice also the pole light fixture.

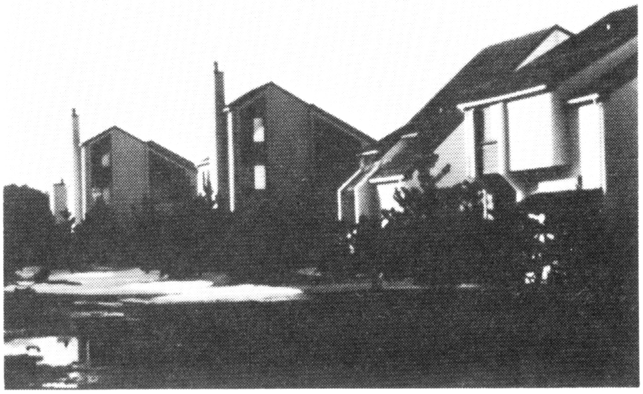
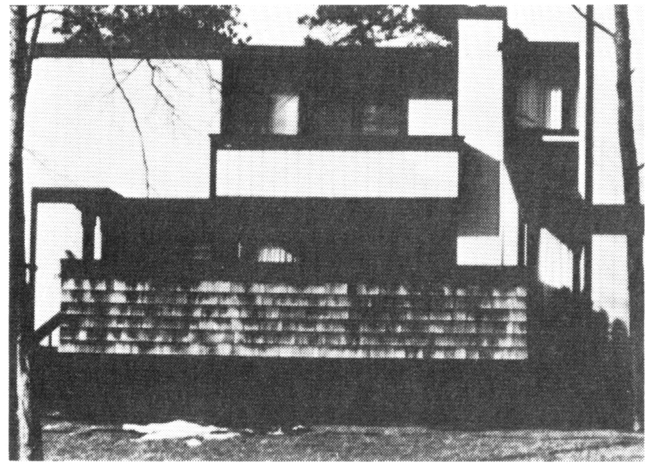


Figure 3.33. Passersby have to look very carefully to see that this development is actually elevated. Good use of landscaping and building form includes attached and detached units.

Figure 3.34. This structure uses a mixture of materials, texture and color very successfully and provides a variety of form for visual appeal. The space under the building remains open and light through a combination of white unobstructed walls and piers, landscaping, and layout relative to other buildings. A human scale is accomplished by breaking the building up into different heights and sections, rather than an imposing three-story box, as is often done (see also Figures 3.58 through 3.62).



Figures 3.35 and 3.36. This is a good example of using a variety of shapes and forms (wall surfaces, planes, balconies, etc.) as well as wall treatments (materials, texture, color) to create a sense of variety essential for an aesthetically pleasing development.

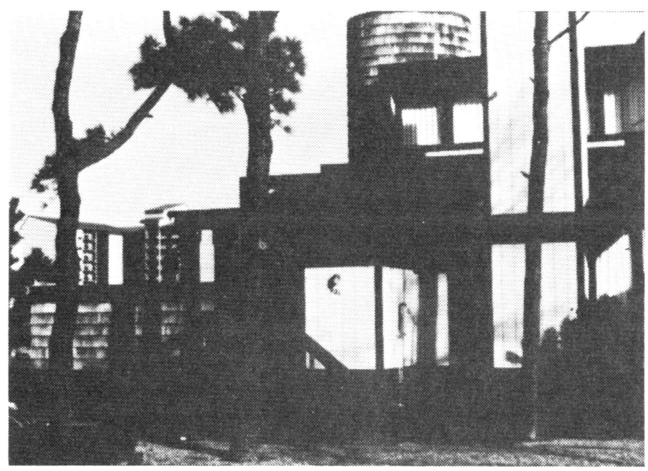
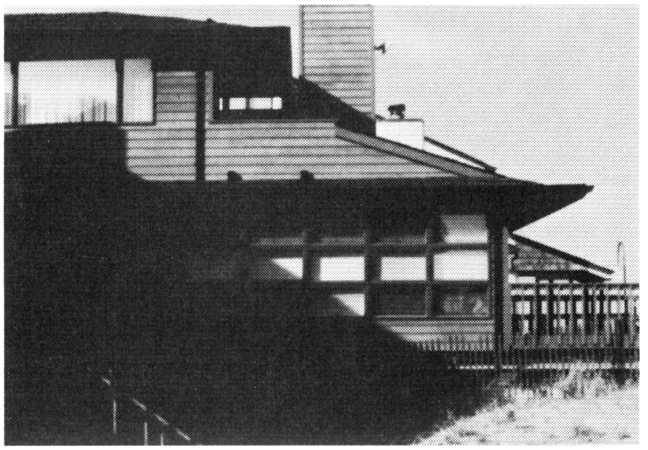


Figure 3.37. In the interior, color, scale, texture, and floor arrangement must be given careful attention (see also Figures 3.40 through 3.45).



Figures 3.38 and 3.39. Well-designed elevated residential structures can take many forms and styles. The principles in this manual are applicable to any style.

Recent Design Examples

The projects in this section are some of the best design examples discovered in a state-of-the-art survey conducted as part of the development of this manual. While these examples range from a single-family detached unit to a multi-family high rise, there appears to be a clear trend toward higher density, cluster-type development. This is probably due to higher land values and the experience gained from major floods over the last couple of decades. This is a promising trend that encourages professional design involvement in residential structures and leads to a more comprehensive approach to elevated residential and other development in flood-prone areas.

Virtually all the recent design examples that were submitted in response to our survey were coastal, as opposed to riverine, projects. This suggests that the state of the art is being set for the most part in coastal areas, especially in the higher-use resort areas. It should be noted, however, that what is being done in coastal areas can often be applied successfully in riverine, lake, and other flood-prone areas as well.

Figure 3.40

THE LOGAN HOUSE

Tampa, Florida
Architects: **Rowe Holmes Barnett Architects, Inc., Tampa, Florida**

The Logan House (Figures 3.40 to 3.45), located adjacent to a federally protected tidal estuary near Tampa, Florida, exemplifies a skillful blend of flood protection and energy conservation. The natural site of the house, only four feet above sea level, suggested the possibility of flooding. Flood regulations required Rowe Holmes Associates to elevate the structure an additional six feet. They chose, however, to raise the house almost eight feet to be able to use the first level as both a carport and protected outdoor living area.

The 2,000-square-foot structure is designed in what is known in Southern vernacular as the "dog trot" style, incorporating a long breezeway/ventilating device covered with the same roof as the house but open on the sides. The wood frame house is supported on 10-inch-square pressure-treated pine poles augered deep into the soil to withstand hurricane forces common to this area of the country. The floor serves as a horizontal diaphragm to provide the pole structure additional rigidity.

Several of the features that protect the Logan House from flood damage also promote energy conservation. For example, elevating the structure, the major flood protection strategy, helps draw cool (lower) air up and through the house.

A central utility core—unfortunately located on the lower level where it is vulnerable to storm forces—is serviced by a stairway, allowing protected access to the carport and outdoor space.

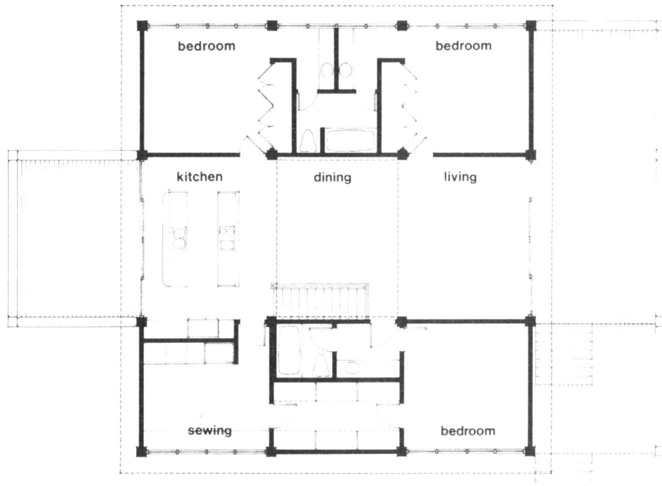


Figure 3.41 **living level**

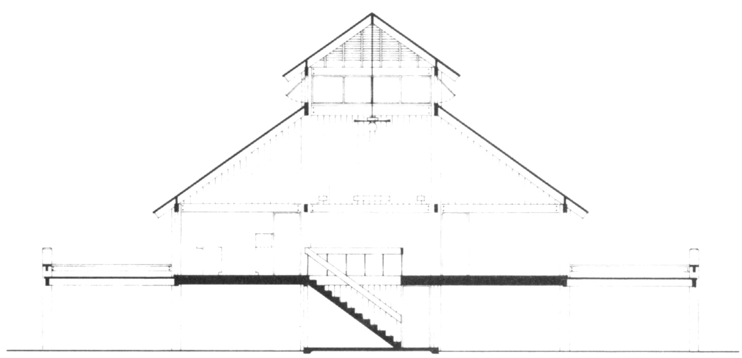


Figure 3.42 **section**

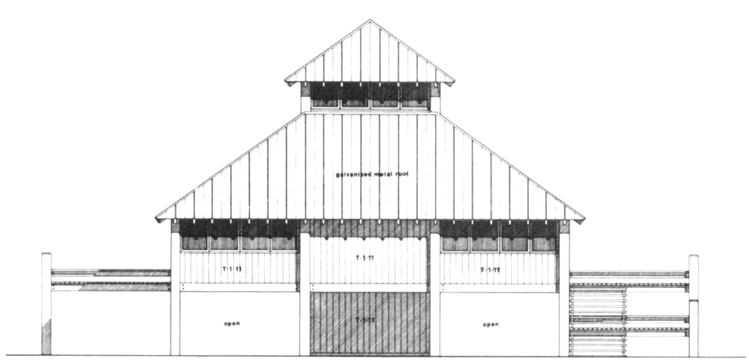


Figure 3.43 **south elevation**

Figure 3.44

Figure 3.45

SUMMERWOOD ON THE SOUND
Old Saybrook, Connecticut
Architects: Zane Yost & Associates, Inc.,
Bridgeport, Connecticut

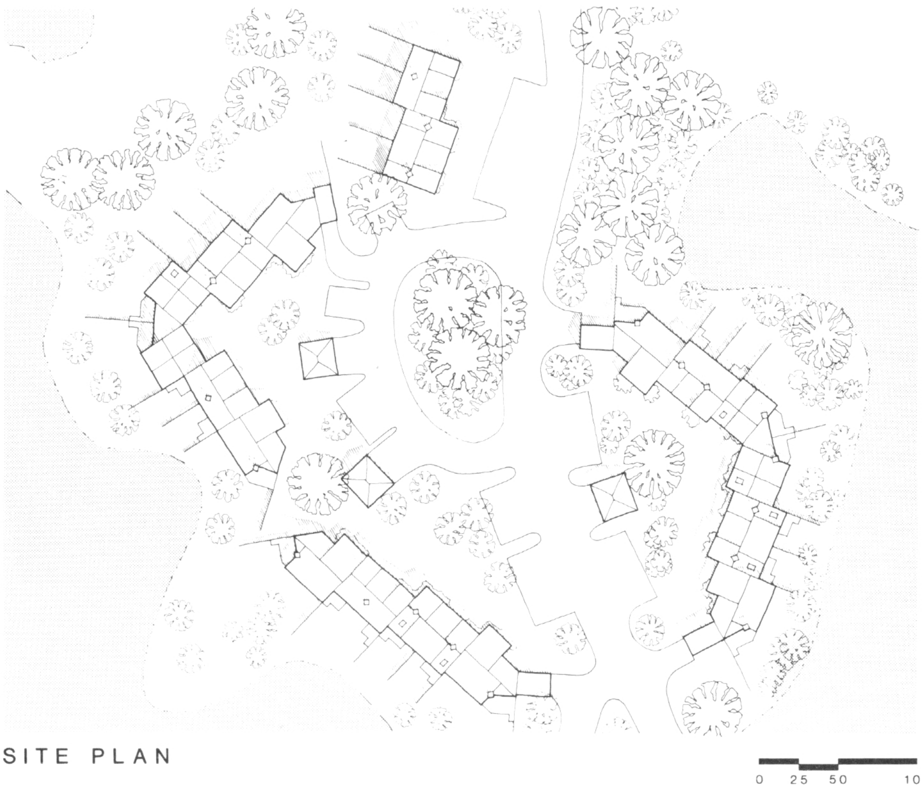
Summerwood on the Sound (Figures 3.46 to 3.50), a 76-unit cluster development, won a 1979 design award for architects Zane Yost & Associates, Inc. The development is built on a peninsula tidal estuary protected by a barrier beach.


Figure 3.46

Equal in importance to protecting the buildings from flooding was the preservation of the salt marsh ecological environment. For this reason, the architects chose to locate the units only along the natural contours of the 30-acre site. For further protection of land as well as buildings, the structures are elevated above flood level, topping crawl spaces with internal drains to permit flood water to pass in and out. The wood frame structures are covered with horizontal siding and use picket fences to soften the effect of the raised structures. Redwood stairs and decks adorn the water side of the units.

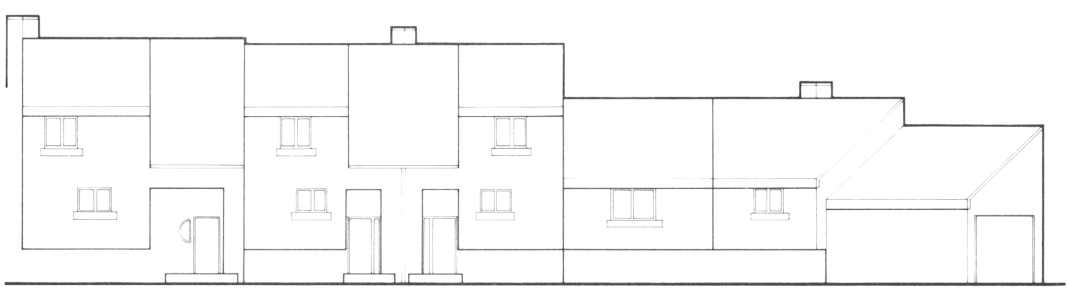
Although the overall density on the site is low (2.5 units/acre), the clustering of the units makes for a comfortable neighborhood scale.


Figure 3.47

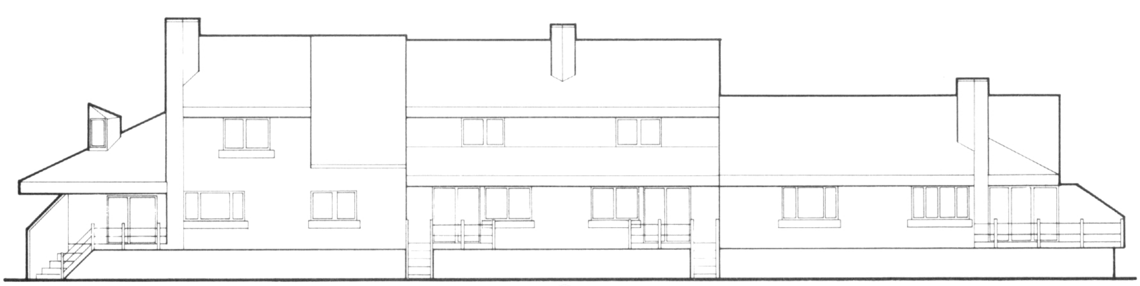


SITE PLAN

Figure 3.48



Front Elevation



Rear Elevation

Figure 3.49

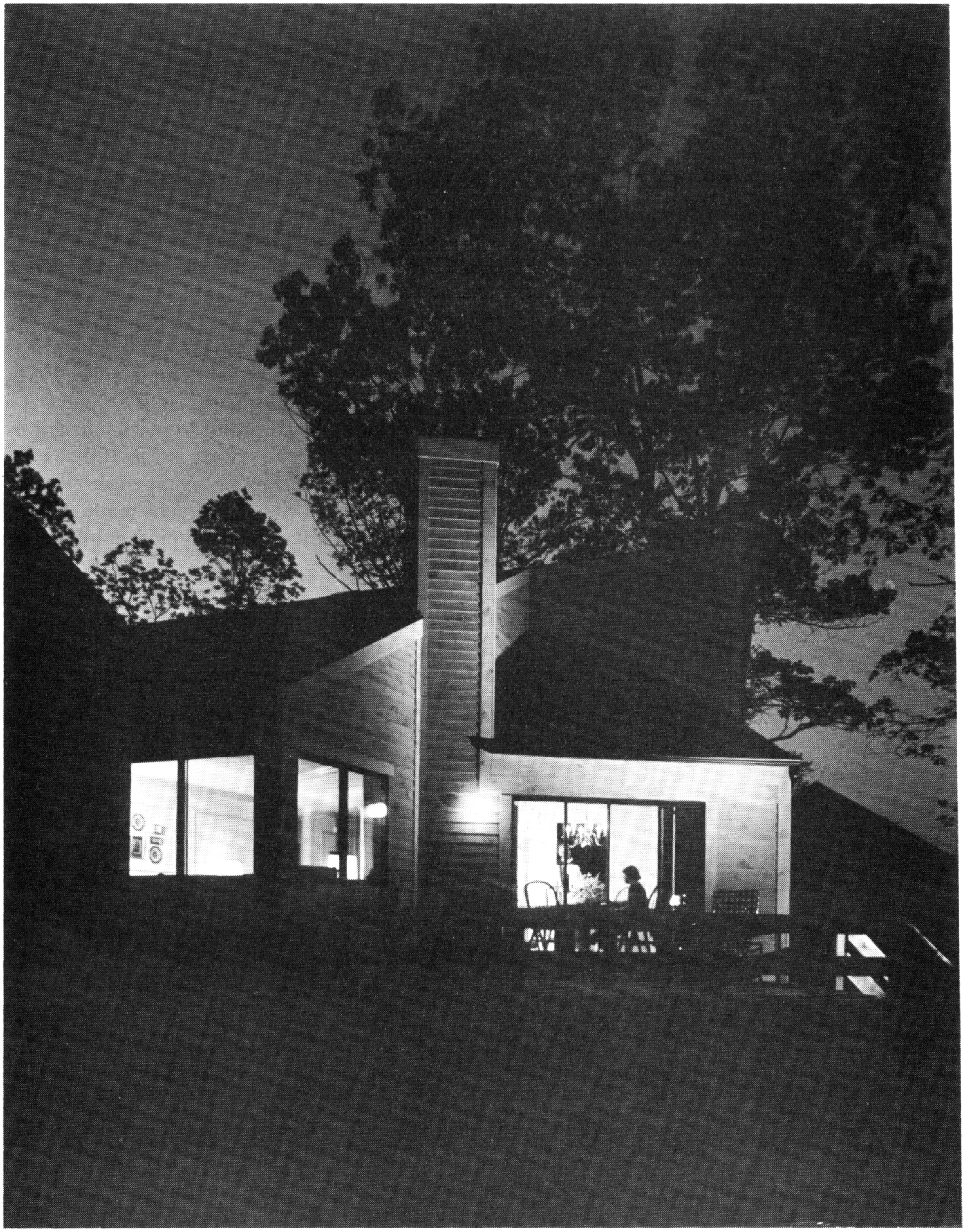


Figure 3.50

THE BREAKERS CONDOMINIUM

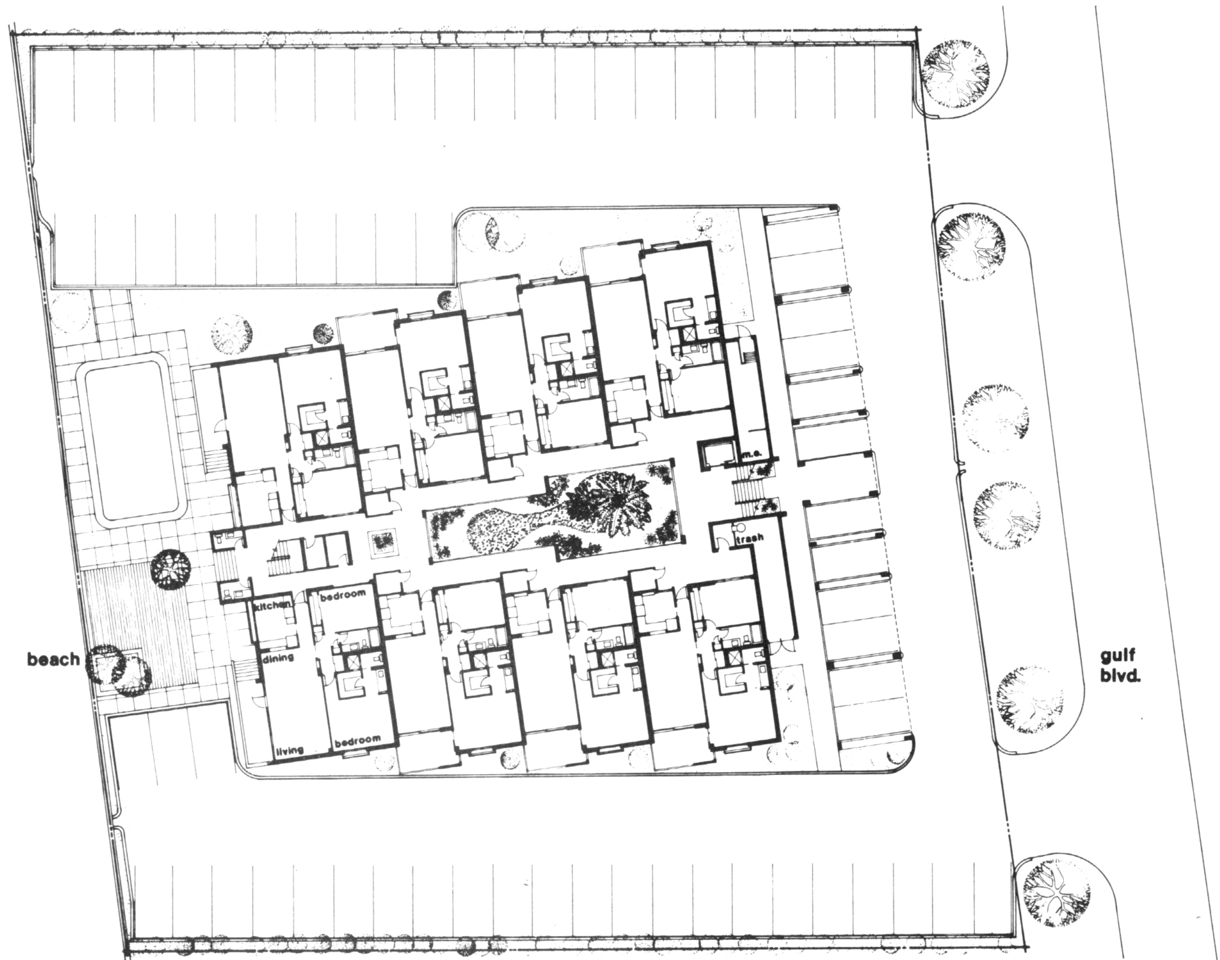
Redington Beach, Florida
Architect: Rowe Holmes Barnett Architects, Inc., Tampa, Florida

The Breakers Condominium in Redington Beach, Florida (Figures 3.51 to 3.53), is composed of 38 two-bedroom units oriented to take advantage of a spectacular ocean view. Using a "double saw-tooth stepback" plan, the architects oriented the buildings around a communal atrium garden, creating a pleasant internal garden on an otherwise flat and treeless site.

The 1,200-square-foot units, completed in 1973, are composed of exterior masonry walls and flat-slab and column construction to reach a height of 12 feet above sea level, which is the 100-year high flood elevation. A heavy Spanish stucco finish and louvered privacy screens made of redwood soften the effect of the typical condominium construction.

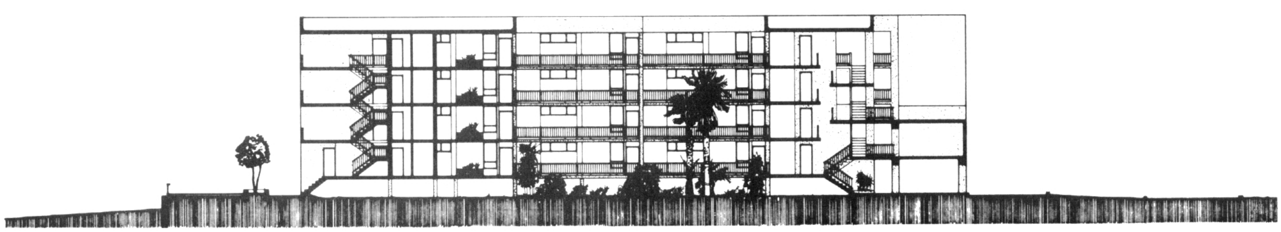
All the units share the atrium garden on either their entry or walkway sides. The units also share a game room and beachside pool and deck.

Figure 3.51



site and first floor plan

Figure 3.52



longitudinal section

Figure 3.53

CAMPUS-BY-THE-SEA FACILITY
Catalina Island, California
Architect: Leonard E. Lincoln, AIA,
Palo Alto, California

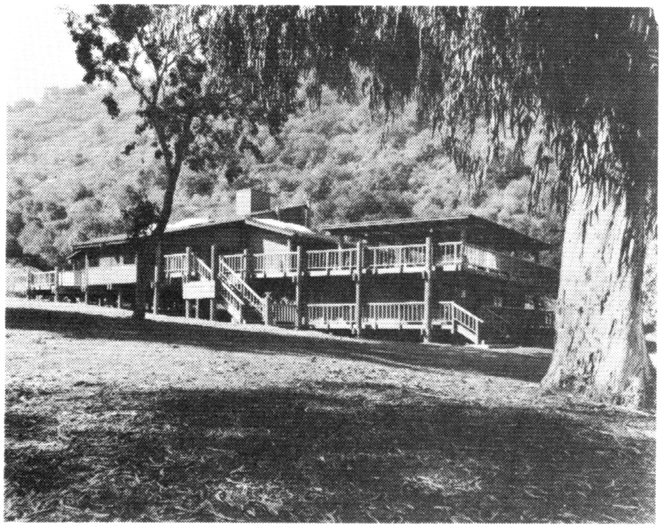


Figure 3.54

Catalina Island (Figures 3.54 to 3.57), developed as a resort center in the 1920s, is located 21 miles off the coast of southern California. Many of the original structures built on the island were destroyed by flash floods in 1980 when storm waters cascading down a series of ravines swept them off their concrete pier foundations.

The newly replaced key facilities of Campus-by-the-Sea, a conference center, are no longer threatened by such flooding. For example, the new three-level dining complex makes use of poles that serve as both foundation and roof support for the 7,000-square-foot structure. The structure is supported by 55 poles, ranging from 25 to 40 feet in length. These poles are set on concrete pads, which were poured at the base of 10-foot-deep caisson holes. The poles were specially pressure-treated to resist decay and termite attack. A preservative (pentachlorophenol) was carried by a low-viscosity petroleum gas, allowing for deep penetration through the sapwood into the heartwood.

Several of the new two-unit cabins on the site have also used this kind of structure, and more similar construction is expected to take place in the near future.

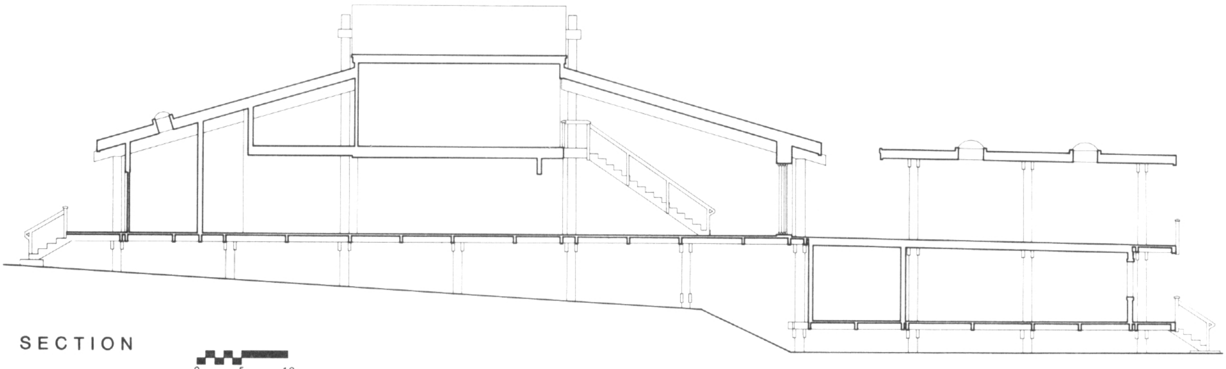


Figure 3.55

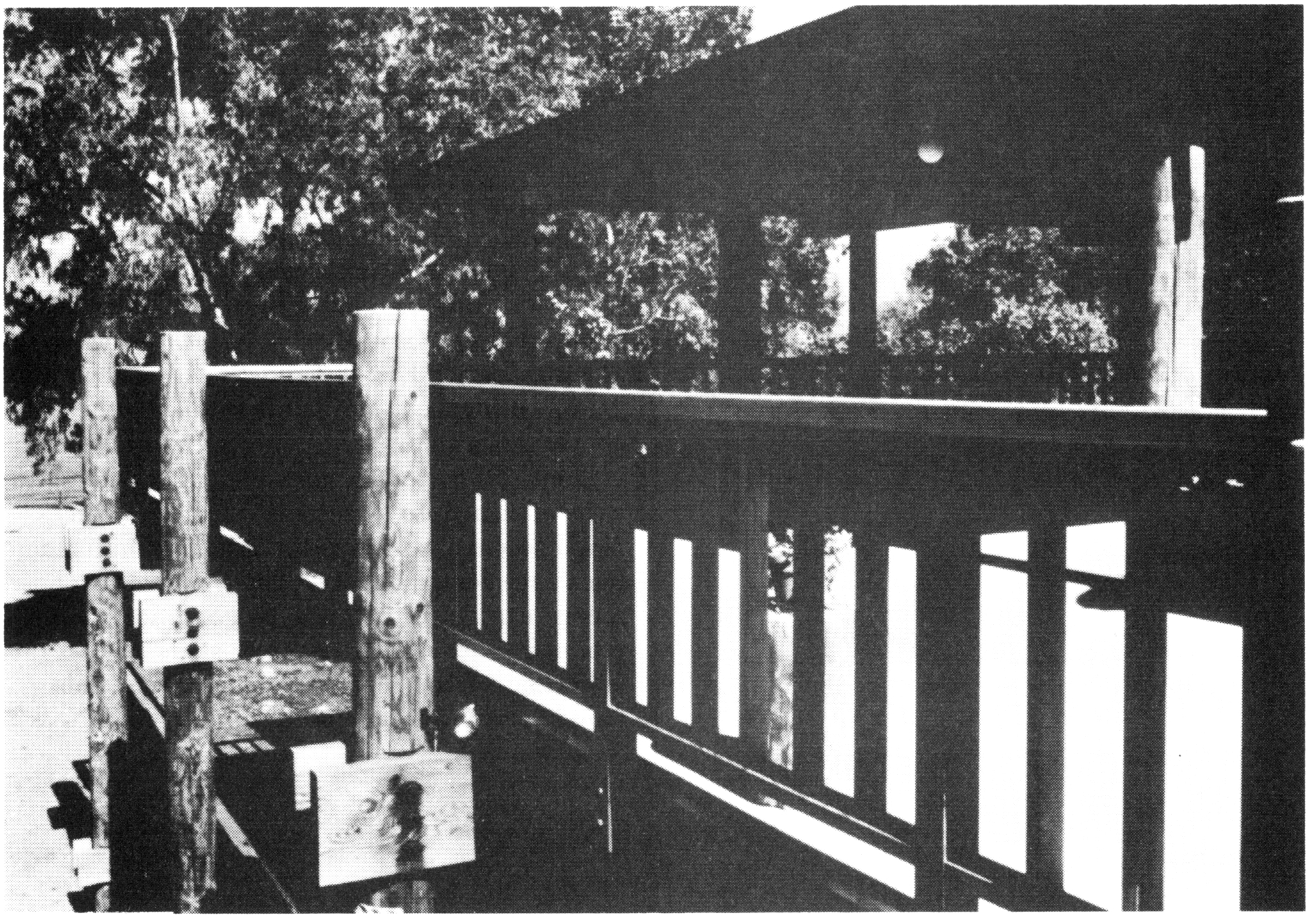


Figure 3.56

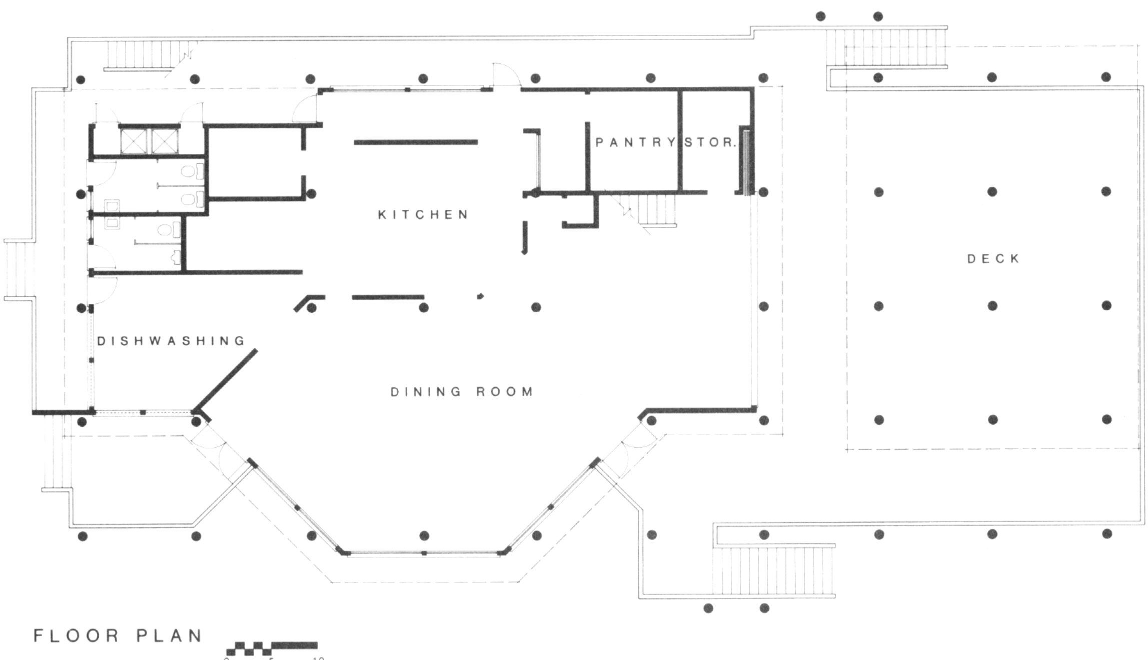


Figure 3.57

STARBOARD VILLAGE
Pensacola Beach, Florida
Architects: Davis & Associates,
Architects & Planners, PA,
Orlando, Florida

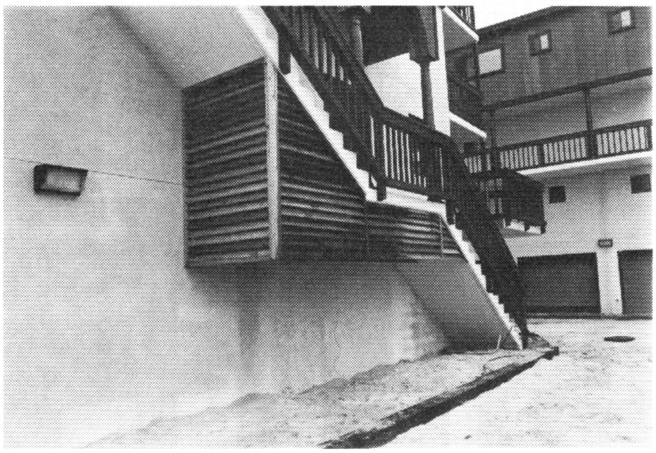


Figure 3.58

Starboard Village (Figures 3.58 to 3.62) is a 33-unit condominium project consisting of six low-rise buildings on the Gulf of Mexico. All the living areas are raised above grade, allowing parking at ground level. Each building is designed with a module using a one-story unit with two-story units above. All structures are concrete frame and slab systems, supported on concrete-piling with shear walls designed to withstand hurricane forces. Wood-accented stucco as the primary finish maintains a residential quality. The architects exercised special care in locating the air-conditioner units, mounting them under concrete stairs and on the underside of the second floor concrete slabs. Wood louvers then enclose the units.

Figure 3.59

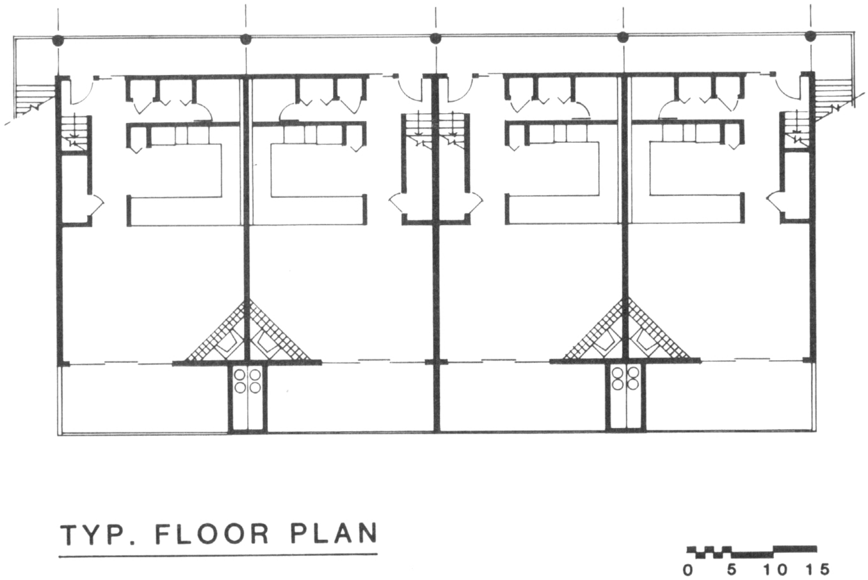


Figure 3.60

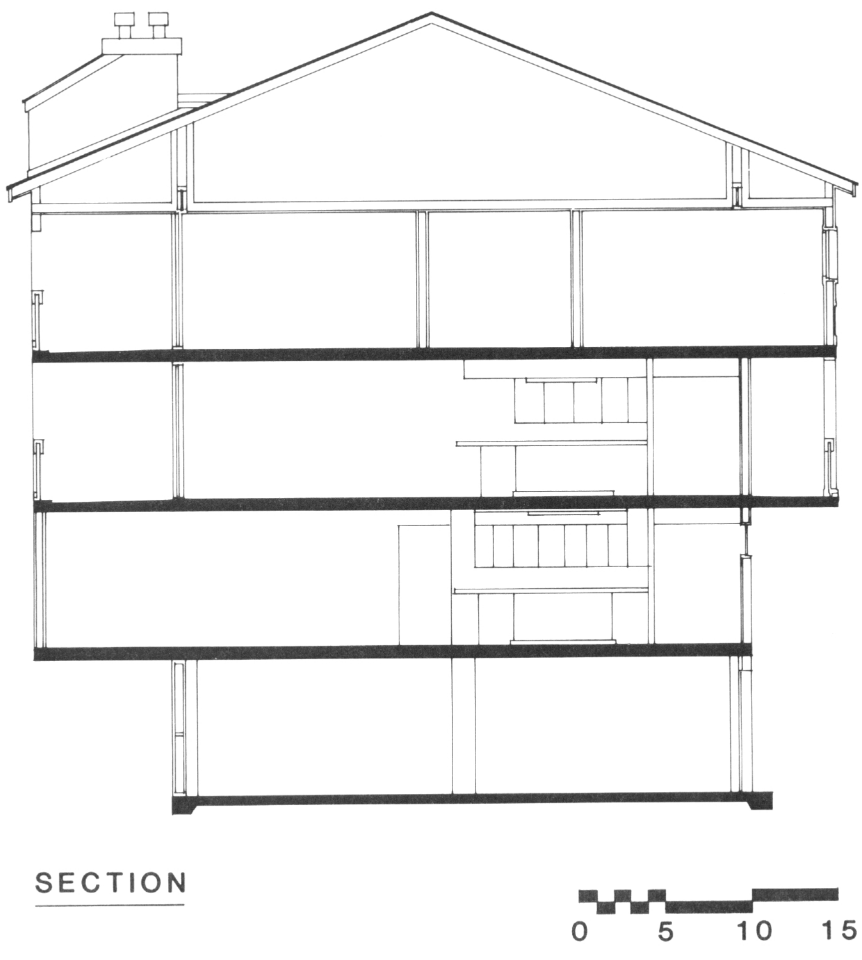


Figure 3.61

Figure 3.62

GULL POINT CONDOMINIUMS
Perdido Key, Florida
Architects: H. Shelby Dean—Richard H. Fox, Architects, Anniston, Alabama

The design of this 16-unit condominium (Figures 3.63 to 3.70) on the Gulf of Mexico successfully integrates storm protection, energy conservation, function, and economics.

The architects used pile construction to elevate the units several feet above the minimum required by the National Flood Insurance Program. This was done because analysis of the flood insurance premium rate structure showed that the added margin of safety from the additional elevation would qualify the units for significant savings in annual insurance costs.

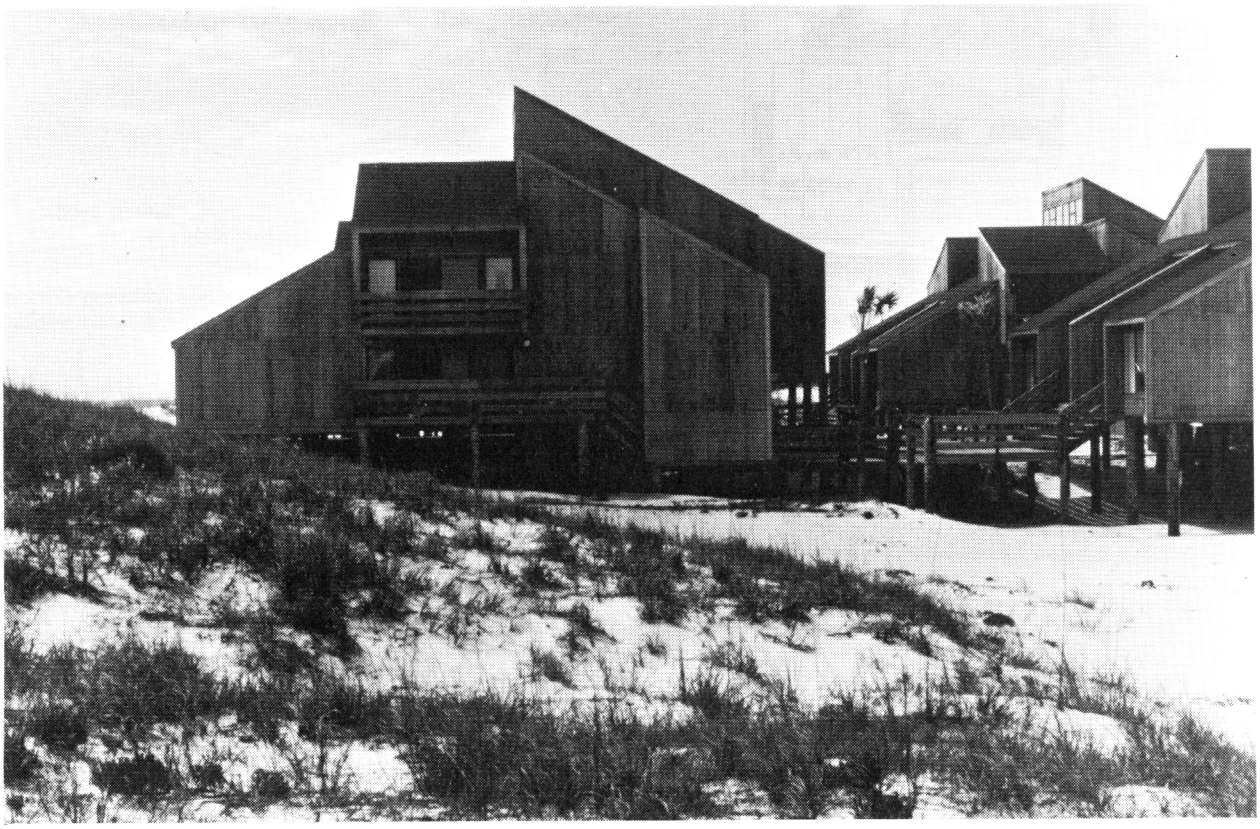


Figure 3.63

The buildings' exteriors are of cedar. The buildings were configured to reduce the impact of hurricane winds while maximizing views and privacy. At the same time, fenestration was placed to maximize natural ventilation. This and the use of insulated glass have reduced the need to use the units' air-conditioning.

A variety of forms and shapes provide visual interest and a variety of living spaces for the units' occupants, who use the units mostly as vacation homes. The units are situated around a central pool and landscaped area, which provides the occupants a well-defined community space.

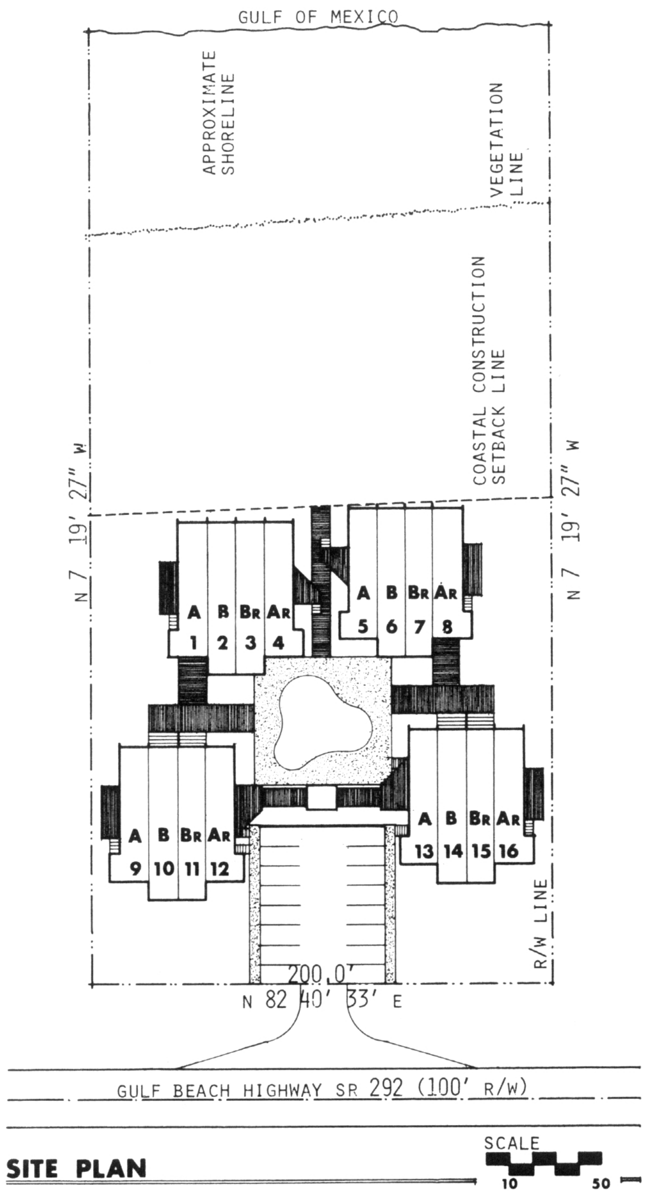


Figure 3.64

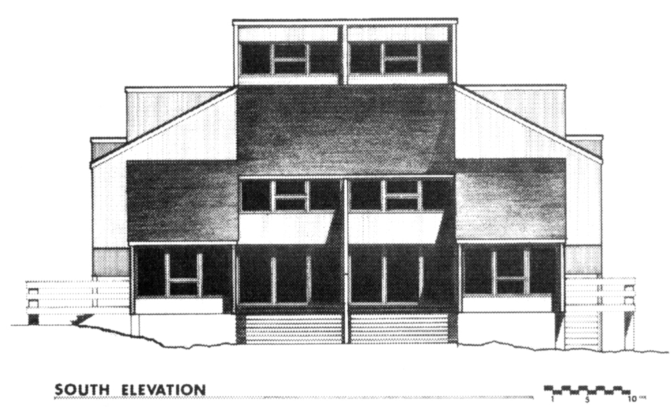


Figure 3.65

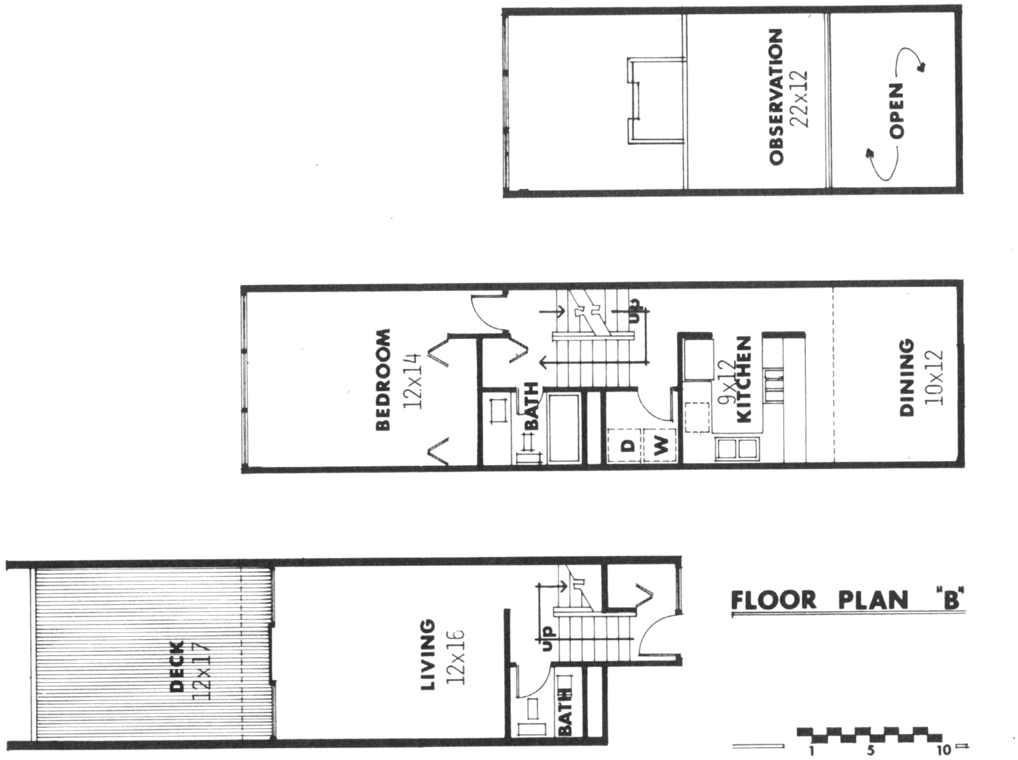


Figure 3.66

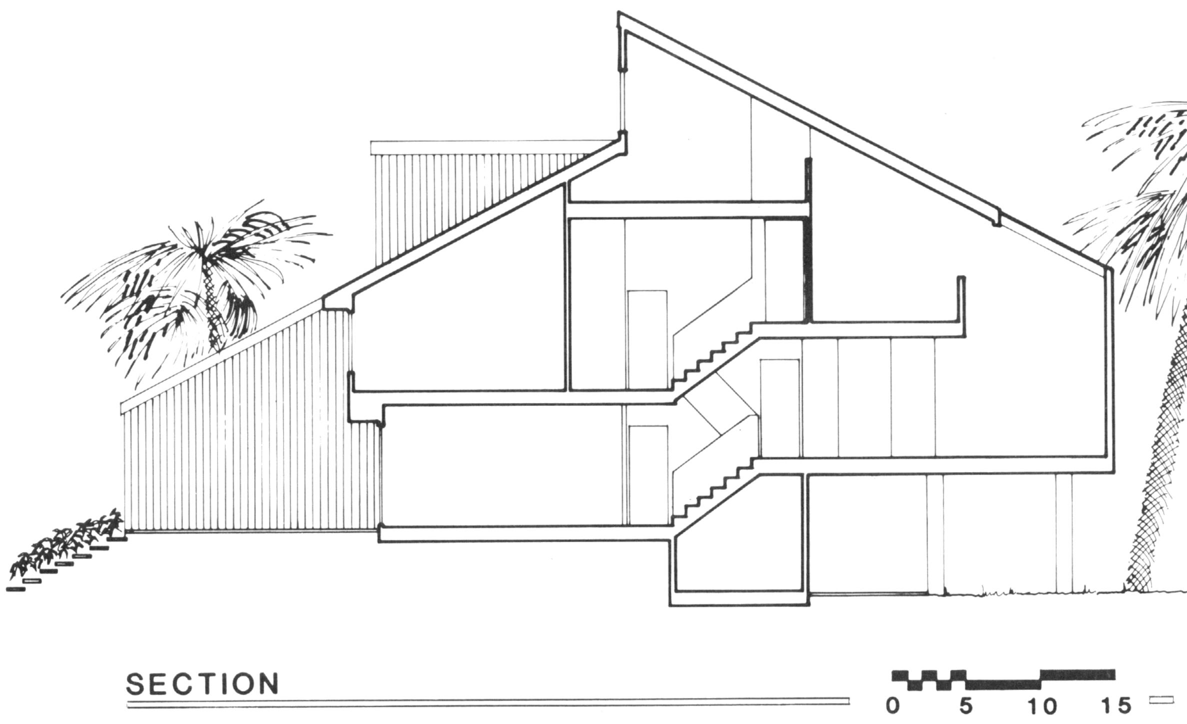


Figure 3.67

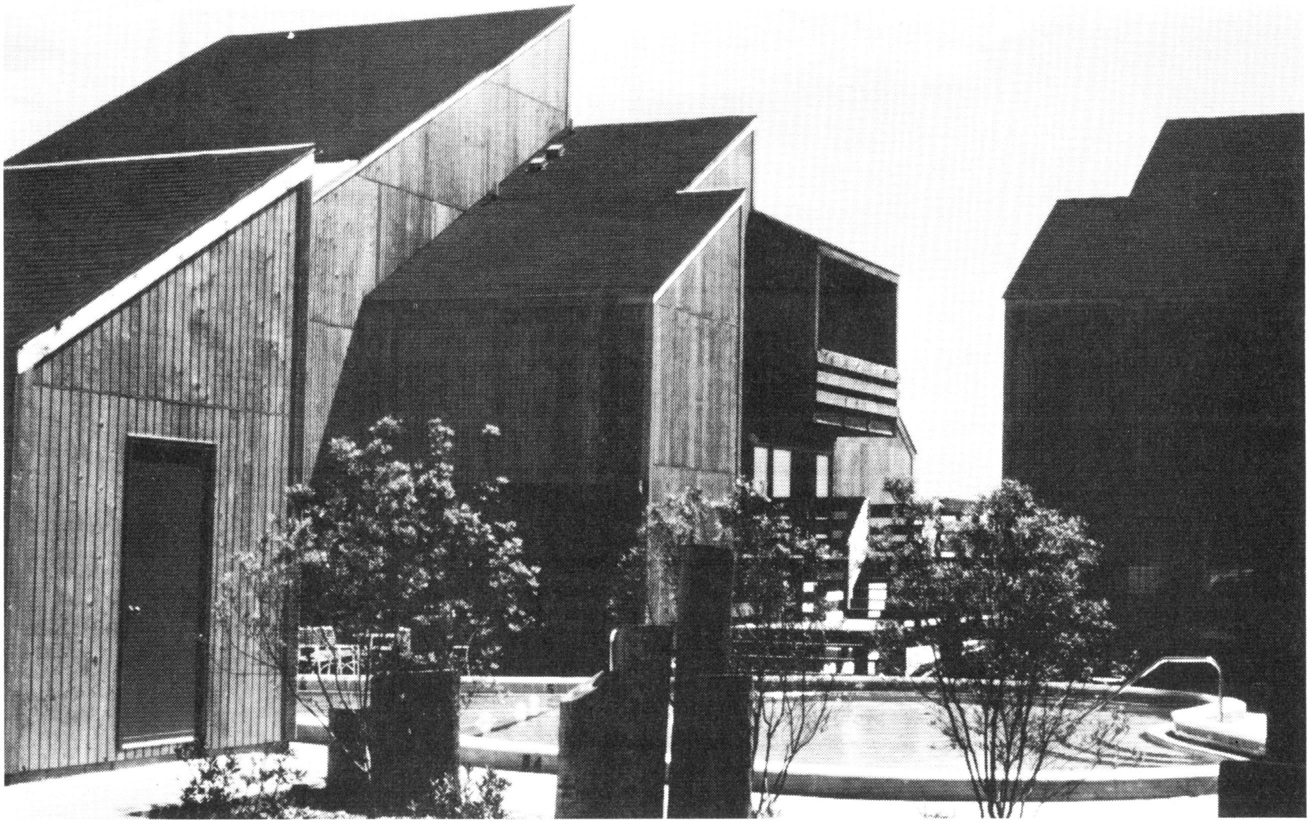
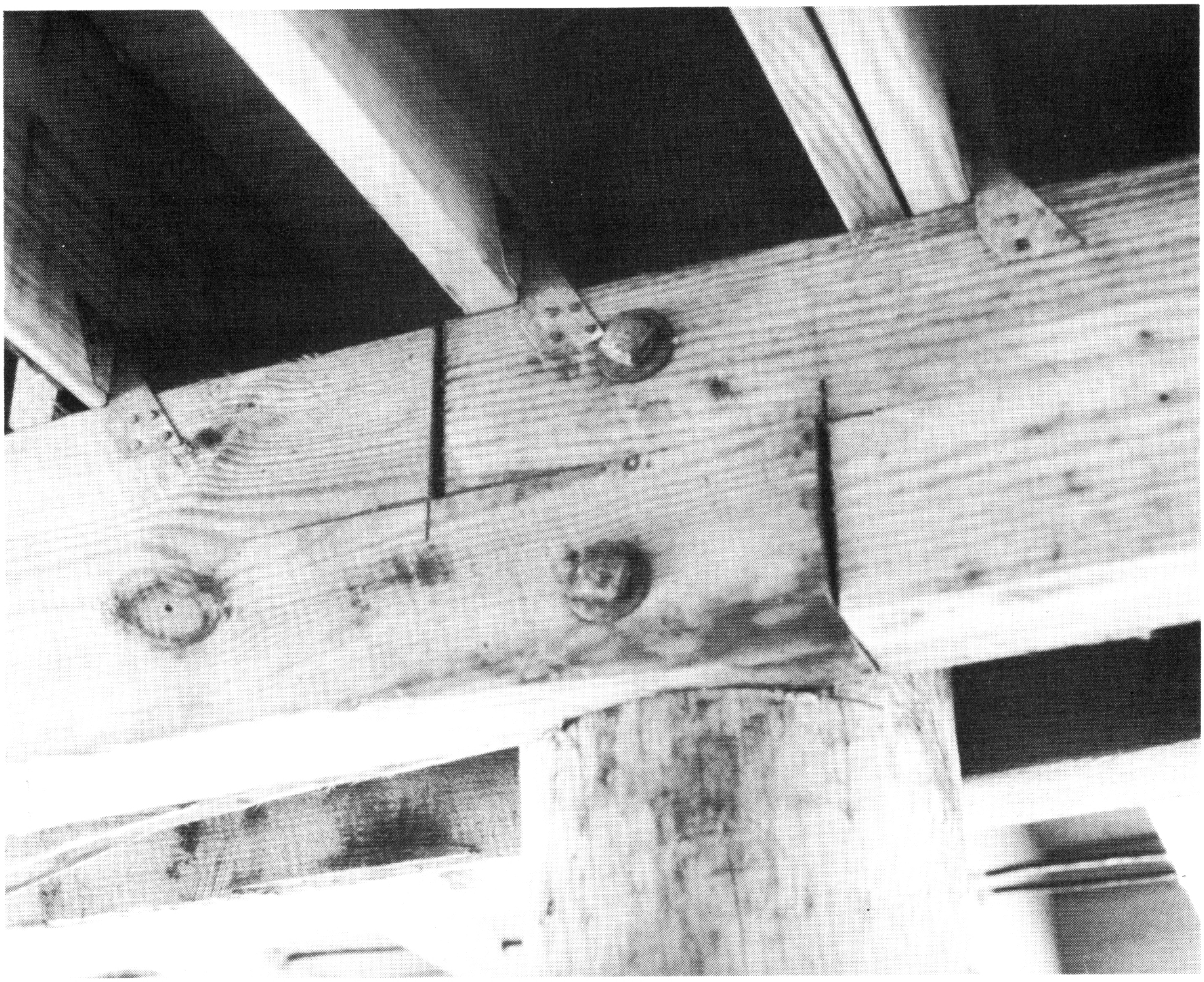


Figure 3.68

Figure 3.69

Figure 3.70



Foundations

The common methods of elevating residential structures are earth fill, elevated foundations, shear walls, posts, piles, and piers. The selection of an elevation technique depends on a number of variables, including hydrologic factors, physical conditions at the site, and cost. The determination of the appropriate technique requires analysis of these factors in the context of federal, state, and local regulatory requirements. In some cases it can be advantageous to use a combination of elevation methods. For example, a building raised on fill at one end and piers or posts at the other could provide ground floor access at the end of the building away from the floodplain while minimizing obstruction of flood waters at the end nearer the stream channel.

The following discussion of the design and construction of elevated residential structures is based on accepted building practice. Generally, a conservative approach has been taken in order to ensure compliance with the building codes most widely used in the United States. In addition, the performance criteria presented later in this manual can be used to review a building's expected response to flooding. Analysis of flood-induced loads and soil conditions, as well as normal loads, stresses, and deflection of structural members, is required to ensure satisfactory building performance.

Note that foundations in V Zones should be designed in accordance with *Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas*, cited in the Preface.